F° 102 ● 36 RR (1)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 887 318 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.12.1998 Bulletin 1998/53

(51) Int Cl.[6]: **C03B 37/012**, C03B 29/14, C03B 29/00

(21) Application number: **98305070.9**

(22) Date of filing: **26.06.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **27.06.1997 JP 171439/97**

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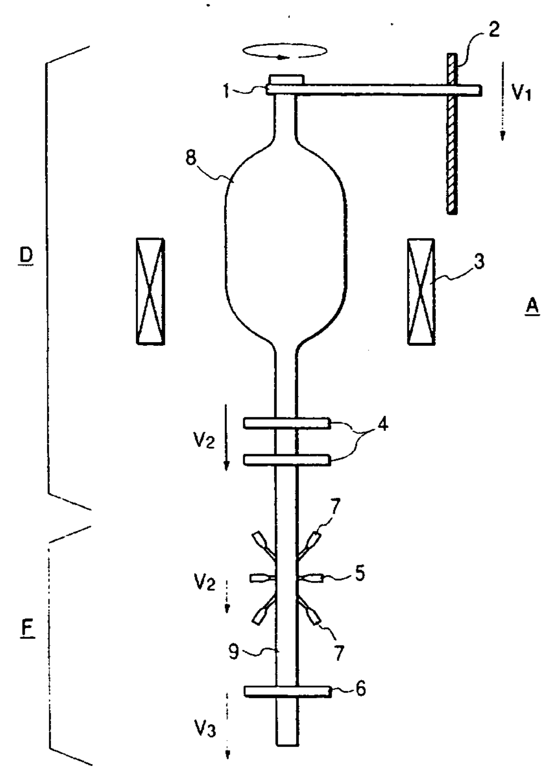
(54) **Method and apparatus for fusing an optical fiber preform**

(57) A method for fusing an optical fiber perform comprises fusing the preform while blowing an oxidative gas against the preform to be fused from upper and lower directions of a fusing burner unit. An apparatus for carrying out the method includes a plurality of nozzles for preventing deposition of silica cloud, which are each set at an angle, θ, of blowing the oxidative gas relative to the preform being drawn such 20°≤θ≤60°.

FIG. 1



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Description

This invention relates to method and apparatus for making an optical fiber preform, and more particularly, to improved method and apparatus for making an optical fiber preform wherein when a large-sized mother ingot for optical fiber is thermally drawn along a vertical direction and is fused to continuously obtain rods with a tapered portion at opposite sides thereof, deposition of a so-called silica cloud generated in the course of the fusing can be well prevented.

An optical fiber preform is obtained by drawing an ingot to have a given diameter depending on a fiber drawing machine used. If the ingot has a bend, such a bend is corrected during the course of the drawing. Thereafter, a dammy glass is welded to the preform at opposite sides thereof, followed by drawing by use of a fiber drawing machine. The optical fiber made of silica glass and flawed in the surfaces thereof becomes very embrittled. Accordingly, if an optical fiber is flawed at the time of the fiber drawing of an optical fiber preform, strength lowers. For the purpose of suppressing the occurrence of flaws, fire polishing has been usually effected wherein after finishing with a given diameter, an optical fiber preform is exposed to a weak flame to remove foreign matters from the outer surfaces thereof.

As is known in the art, when a preform is heated until its surface temperature arrives at about 2000°C, part of the silica glass sublimates into SiO. This SiO combines with moisture present in a surrounding atmosphere and converts again to glass fine particles, followed by re-deposition on the surfaces of the preform. It is also known that when silica glass is fused by means of a flame, a so-called silica cloud appears just outside the strongly heated portion. This cloud has the possibility of flawing the fiber surfaces at the time of the fiber drawing. Thus, it is necessary that the cloud be removed prior to the fiber drawing. The cloud may be removed by slowly heating the rod with a relatively weak flame. In this connection, however, the heating of the preform may become inadequate depending on the amounts of gases used and the moving speed of a burner. This leads to a great strain being left in the preform, with the great possibility that only a slight degree of impact applied to the preform results in cracking. On the other hand, when the preform is heated to an extent greater than required, a residual strain becomes small, but with the re-appearance of a band-shaped cloud.

To avoid this, it is usual to measure a residual strain by use of a strain gauge and determine fire polishing conditions in such a way that gas conditions and burner moving speed conditions, under which a residual strain is at a level involving no problem therein, and also gas conditions and burner moving speed conditions, which are determined by appearance inspection, are determined by trial and error. As a matter of course, these conditions differ depending on the diameter of a preform and the nature of individual burner. Accordingly, the work for determining these conditions has, in fact, required much labor and time. In addition, in view of the results of the determination of these conditions, it is required that in order not to cause any cloud to develop, a relatively weak flame be used so that the surface temperature of a preform is not raised and that in order to make a small residual strain, the moving speed of a burner be low sufficient to permit heat to be satisfactorily transmitted to the inside of a preform. These requirements need much time. More particularly, to fuse a preform by a conventional manner allows a silica cloud to be deposited and once again requires fire polishing at a final stage. The work of determining the final-stage fire polishing further requires much time and labor.

It is therefore an aim of the invention to provide a method for fusing an optical fiber preform while reducing or preventing deposition of a silica cloud generated at the time of heating the preform in a fusing step of a continuous process of manufacturing preform rods with a tapered portion at opposite sides thereof by drawing a large-sized mother ingot in an electric furnace in a vertical direction and subsequently fusing the drawn preform.

It in another aim of the invention to provide an apparatus for fusing an optical fiber preform whereby a silica cloud deposited on a tapered portion at opposite sides of preforms can be reduced or prevented.

According to one embodiment of the invention, there is provided a method for fusing an optical fiber preform which is obtained by drawing a large-sized mother ingot along a vertical direction under heating conditions and subsequently fusing the resultant preform by use of a fusingburner in the form of a preform piece having a tapered portion at opposite sides thereof wherein the preform is fused while blowing an oxygen gas from upper and lower sides relative to the fusing burner whereby a silica cloud is prevented from deposition on the tapered portion of the preform piece.

According to another embodiment of the invention, there is also provided an apparatus for fusing an optical fiber preform, which comprises a drawing unit having a rotary chuck, a feeding means, an electric furnace, and a drawing chuck, and a fusing unit associated in connection with the drawing unit and having a fusing burner and a fusion chuck, wherein the fusing unit includes a plurality of nozzles located above and below the fusing burner unit and capable of blowing an oxidative gas against a preform being fused at an angle, θ, of the blowing relative to the length of the preform, which is in the range of $20° \leq \theta \leq 60°$.

The invention will be described below with reference to an exemplary embodiment and the accompanying drawings, in which:-

Fig. 1 is a schematic longitudinal sectional view illustrating an apparatus of fusing an optical fiber preform according to the invention; and
Fig. 2 is a schematic, enlarged, longitudinal section-

al view showing a fusing unit of the apparatus of Fig. 1.

Reference is now made to the accompanying drawings and particularly, to Fig. 1. In Fig. 1, there is shown an apparatus A of manufacturing a preform. The apparatus A includes a drawing unit D and a fusing unit F. The drawing unit D has a rotary chuck 1, a feed mechanism 2, an electric furnace 3, and a drawing chuck 4 as shown. The fusing mechanism F includes fusing burners 5, a chuck 6, and nozzles 7 for preventing deposition of a silica cloud.

In operation, an ingot 8 made of silica glass is fixedly attached to the rotary chuck 1 and fed to the electric furnace 3 by means of the feed mechanism 2 at a feed rate V_1. In the furnace 3, the ingot is heated and softened, under which it is drawn by movement of the drawing chuck 4 at a take-up rate V_2. The resultant preform 9 being moved at the rate of V_2 is fused to a given length by means of a fusing chuck 6 at a fusing rate V_3 to obtain a product rod. At this time, the fusing burners 5 and the nozzles 7 are both moved at the rate of V_2, which is equal to the take-up rate, while blowing an oxidative gas against the preform being drawn. The rates V_1, V_2 and V_3 should be so set that $V_2>V_1$ and $V_3>V_2$.

Fig. 2 is a view showing the detail of the fusing unit F of the apparatus A, with which the preform 9 is fused into product rods having a given length. As will be seen from the figure, two fusing burners are located in face-to-face relation via the preform 9, and four nozzles 7 are each arranged at a preset angle, θ, between the flow of an oxidative gas and the preform being drawn. This angle should be in the range of $20° \leq \theta \leq 60°$. If this blowing angle is less than 20°, the nozzles may contact the preform being rotated in view of the structural arrangement of the apparatus. On the other hand, when the angle exceeds 60°, a greater amount of a gas used to the blowing may be necessary for attaining a deposition-preventing effect similar to that attained at the defined angle.

It is known that the sublimation of silica glass proceeds rapidly in a reductive atmosphere. In contrast, the sublimation of SiO can be suppressed when a heating atmosphere consists of an oxidative gas. Examples of the oxidative gas used in the practice of the invention includes oxygen, air, or an oxygen-rich oxyhydrogen flame. The amount of a gas being blown against the preform is in the range of 1/5 to 1/2 of the amount of a gas supplied to the fusing burner. If the amount is smaller, a satisfactory deposition preventing effect may not be expected. On the other hand, if the amount is in excess, the burner flame may be undesirably disturbed, causing the preform to be heated unsatisfactorily.

It will be noted that smaller-size burners may be used as the nozzles.

In the method of the invention wherein product rods having a tapered portion at opposite sides thereof can be continuously manufactured by thermally drawing, into a preform, a large-sized silica glass ingot 8 having an outer diameter, for example, of 100 to 300 mm in a electric furnace 3 in a vertical direction, and subsequently fused, an oxidative gas is blown against the preform from upper and lower directions of fusing burners 5. As described before, when the surface temperature of the preform arrives at about 2000°C, part of the silica glass is sublimated into SiO. This SiO combines with moisture in a surrounding atmosphere and redeposited on the preform surface in the form of fine particles of silica. To avoid this, an oxidative gas is blown against the preform from upper and lower directions of the burner flame to blow the SiO off. Thus, the re-deposition of glass fine particles is prevented.

The invention is more particularly described by way of examples.

Example 1

Using an apparatus of the type shown in Fig. 1, an ingot having an outer diameter of 150 mm was attached to a rotary chuck, and drawn into a preform having an outer diameter of 60 mm at a feed rate of V_1, of 20 mm/minute, a take-up rate, V_2, of 125 mm/minute, and a fusing chuck take-up rate, V_3, of 150 mm. Two fusing burners of a fusing unit were arranged and opposed at an angle of 180°, and two small-size gas burner nozzles were, respectively, set at upper and lower positions relative to the fusing burners so that two burner nozzles at each position were opposed at an angle of 180°, with an angle of blowing against the preform being at 50°.

H_2 and O_2 gases were fed to the fusing burners at rates of 400 liters/minute of H_2 and 230 liters/minute of O_2. For the prevention of silica deposition, 150 liters/minute of O_2 was fed to each burner nozzle.

The resultant preform pieces had a length of about 1000 mm and an outer diameter of 60 mm, on which no silica cloud was deposited. Thus, any finishing fire polishing was not necessary, resulting in the significant reduction of time. Moreover, a residual strain was slightly observed, but at a level of no problem.

Example 2

The general procedure of Example 1 was repeated using the same drawing conditions as in Example 1, except that H_2 and O_2 were passed to the fusing burners at rates of 400 liters/minute and 230 liters/minute, respectively, and air was passed t the respective small-size gas burner nozzles at a rate of 150 liters/minute and blown against the preform at a blowing angle of 30°. As a result, no silica deposition was found on the resultant preform products having an outer diameter of 60 mm, with similar results as in Example 1.

Example 3

The general procedure of Example 1 was repeated

using the same drawing conditions as in Example 1, except that H_2 and O_2 were passed to the fusing burners at rates of 400 liters/minute and 230 liters/minute, respectively, and an oxyhydrogen flame in an oxygen-rich condition was blown against the preform at a blowing angle of 30° while passing 100 liters/minute of H_2 and 60 liters/minute of O_2 to each small-size gas burner nozzle. As a result, no deposition of silica cloud was found on preform products having an outer diameter of 60 mm, with similar results as in Example 1. Moreover, no residual strain was found in the products.

Claims

1. A method of fusing an optical fiber preform which is obtained by drawing a large-sized mother ingot along a vertical direction under heating conditions and subsequently fusing the resultant preform into piece products having a tapered portion at opposite sides thereof wherein the preform is fused while blowing an oxidative gas from upper and lower directions of a fusing burner unit whereby a silica cloud is prevented from deposition on the tapered portions of the preform piece products.

2. A method according to Claim 1, wherein said oxidative gas is blown against said preform at a blow angle, θ, of $20° \leq \theta \leq 60°$ relative to the preform being passed.

3. A method according to Claim 2, wherein said oxidative gas consists essentially of oxygen.

4. A method according to Claim 2, wherein said oxidative gas consists essentially of air.

5. A method according to Claim 2, wherein said oxidative gas consists essentially of an oxyhydrogen flame in an oxygen-rich condition.

6. A method according to any one of claims 1 to 5, wherein said oxidative gas is blown by use of a plurality of burner nozzles.

7. A method according to any one of the preceding claims, wherein said oxidative gas is fed at a rate of 1/5 to 1/2 of a flow rate of a gas mixture fed to said gas burner unit.

8. A method according to any one of the preceding claims, wherein when an ingot feed rate is taken as V_1, a preform take-up rate as V_2, and a fusing rate as V_3, $V_2>V_1$ and $V_3>V_2$.

9. An apparatus for fusing an optical fiber preform, which comprises a drawing unit having a rotary chuck, a feeding means for feeding a mother ingot, an electric furnace, and a drawing chuck, and a fusing unit associated with said drawing unit and having a fusing burner unit and a fusing chuck, wherein said fusing unit includes a plurality of nozzles located above and below said fusing burner unit and capable of blowing an oxidative gas against a preform being drawn at a blow angle, θ, relative to the length of the preform being passed, which is in the range of $20° \leq \theta \leq 60°$.

10. An apparatus according to Claim 9, wherein said plurality of nozzles are each comprised of a small-size burner.

11. A method of manufacturing an optical fiber or a device including optical fibers, the method including fusing an optical fiber preform according to the method of any one of claims 1 to 8.

FIG. 1

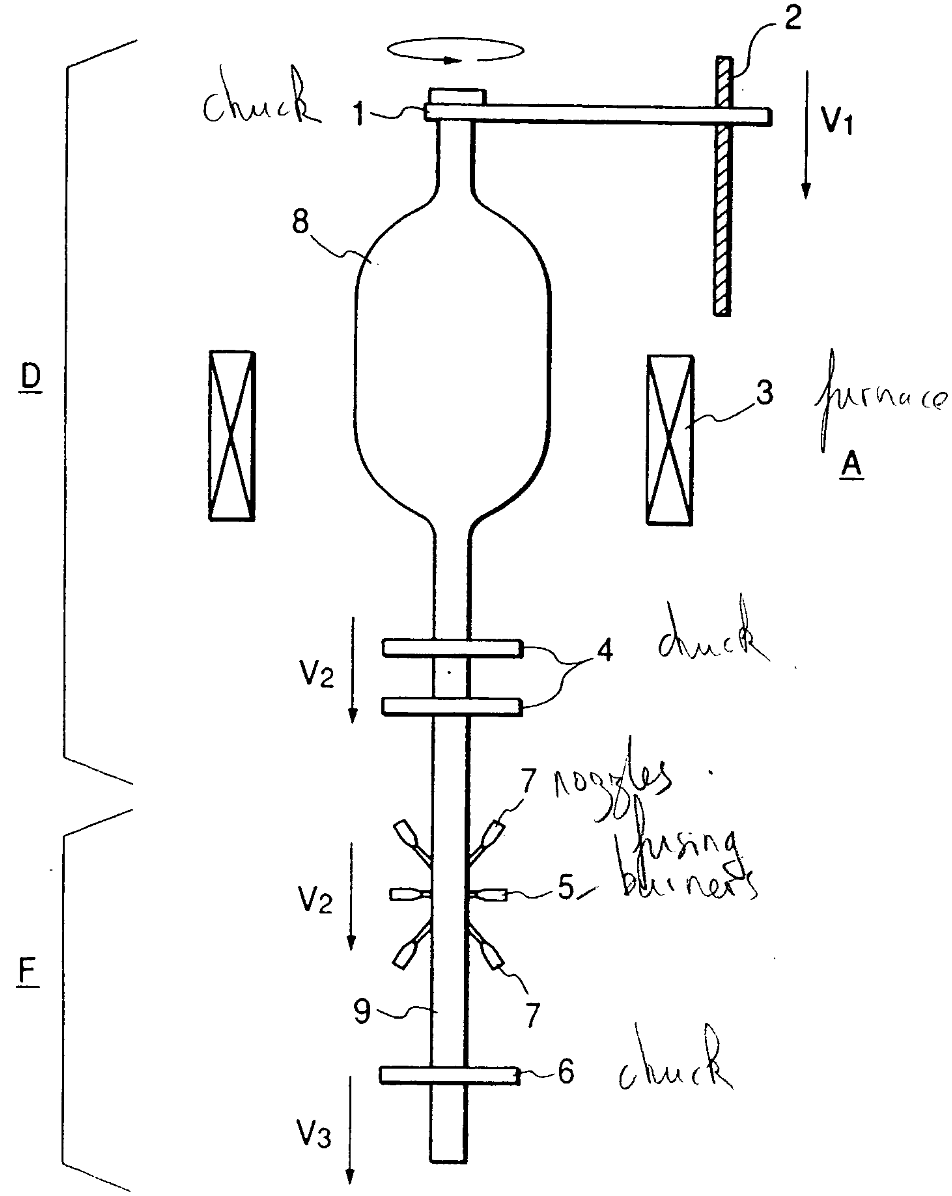
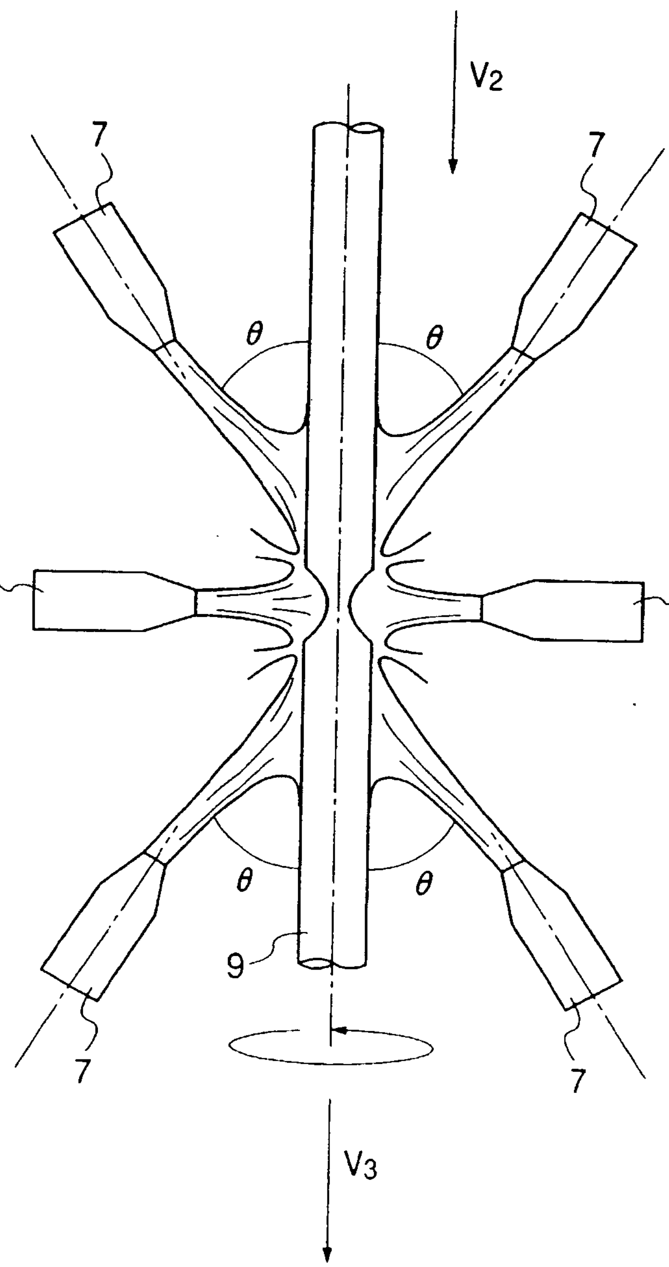

2
chuck
1
V1
8
D
3
furnace
A
V2
4
chuck
7 nozzles
fusing
burners
V2
5
F
9
7
6
chuck
V3

FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 5070

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	FR 2 589 461 A (FIBRES OPTIQUES INDUSTRIES) 7 May 1987 * the whole document * ---	1-3,9	C03B37/012 C03B29/14 C03B29/00
Y	GB 2 307 907 A (SUMITOMO ELECTRIC INDUSTRIES LTD.) 11 June 1997 * the whole document * ---	1-3,9	
Y	EP 0 432 791 A (SUMITOMO ELECTRIC INDUSTRIES LTD.) 19 June 1991 * the whole document * ---	1-3,9	
A	EP 0 519 479 A (SUMITOMO ELECTRIC INDUSTRIES LTD.) 23 December 1992 * the whole document * ---	1,9	
A	EP 0 525 681 A (SUMITOMO ELECTRIC INDUSTRIES LTD.) 3 February 1993 * the whole document * ---	1,9	
A	EP 0 612 700 A (SUMITOMO ELECTRIC INDUSTRIES LTD.) 31 August 1994 * the whole document * -----	1,9	TECHNICAL FIELDS SEARCHED (Int.Cl.6) C03B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 September 1998	Van den Bossche, W

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